The specification has been amended to correct the units of measurement from "nm" to "micrometers." Applicants submit that this is not new matter given the fact these units were provided in the original disclosure as evidenced in the amendment of the units in the Preliminary Amendment submitted in this application. Applicants hereby submit a proposed drawing amendment herewith. The proposed drawing amendment seeks to place the units of measurement provided along the horizontal axis of the table in FIG. 6 in conformity with the above-referenced amendment to the specification. Specifically, the units were changed from "nm" to "micrometers". Application respectfully requests entry of the aforementioned amendments.

The specification was objected to based upon three informalities. Specifically, the Examiner noted that there was no recitation that the application is a 371 of a PCT application. The specification has been amended to include a cross-reference to PCT Application Number PCT/US99/28038, filed on November 24, 1999 which takes priority from U.S. Provisional Application Number 60/109,898, filed on November 25, 1998. The Examiner also pointed out that Figures 4, 5 and 6 are enclosed but not discussed in the specification. Therefore, the specification has been amended to make reference to Figures 4, 5 and 6. The Examiner further noted that the disclosure recited a plot of counts in Figure 3, but instead shows current v. applied voltage. This portion of the specification has been clarified to include a reference to Figure 4 instead of Figure 3. However, in amending the specification to refer to Figure 4, a reference to Figure 3 was deleted. Thus, the specification was further amended to include a reference to Figure 3. As a result of the aforementioned amendments, Applicants hereby request that the objections to the specification be withdrawn.

Claims 2, 3 and 13 were rejected under 35 U.S.C. § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventors, at the time the application was filed, had possession of the claimed invention. Applicants submit there is sufficient written description provided in the specification regarding the homojunction diode provided in claims 2, 3 and 13. Specifically, the present application states that "the invention can be implemented in a large number of other ways, including homojunction diodes," which reasonably conveys to the artisan that the Applicants had possession of the claimed subject matter. See Page 4, lines 24-26; Page 9, lines 24-26 of the present invention; In re Gosteli, 872 F.2d 1008, 1012, 10 USPQ.2d 1614, 1618 (Fed. Cir. 1989). Moreover, claims 2, 3 and 13 themselves, as originally filed, demonstrate that the Applicants were in possession of a sensing mechanism that is inherent in the boron carbide layer, and a neutron detection device that is a homojunction diode. See In re Koller, 613 F.2d 819, 204 USPQ 702 (CCPA 1980) (stating the original claims constitute their own description). Therefore, Applicants hereby request that the rejection based upon 35 U.S.C. § 112, first paragraph, be withdrawn.

Claims 2, 3 and 13 were also rejected under 35 U.S.C.§ 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. In particular, the Examiner stated that there was no enabling disclosure regarding the homojunction diode in claims 2, 3 and 13. "The test of enablement is whether one reasonably skilled in the art could make or use the invention from the disclosures in the patent coupled with the information known in the art without undue experimentation." United States v. Telectronics, Inc., 857 F.2d 778, 785, 8 USPQ.2d 1217, 1223 (Fed. Cir. 1988). One of the many factors to be considered when determining whether there is sufficient evidence

to support a determination of undue experimentation includes the state of the prior art. See In re Wands, 858, F.2d 731, 737, 8 USPQ.2d 1400 (stating the analysis must consider all of the evidence related to each of the factors).

Applicants submit that a nickel doped boron carbide homojunction diode has been reported in the prior art. See Seong-Don Hwang et al., *Fabrication of n-type nickel doped $B_5C_{1+\delta}$ homojunction and heterojunction diodes*, 70 APPLIED PHYSICS LETTER 1028 (1997) (this reference was provided in the Information Disclosure Statement dated May 25, 2001). This prior art would enable one reasonably skilled in the art to make or use the present invention by incorporating a homojunction diode without undue experimentation. As provided in the present patent application, the novel aspect of the present invention is the use of boron carbide as an electrically active semiconductor (Page 3, lines 7-8). The test device as shown in FIG. 2 of the present invention may be set up and used as a sensing mechanism for the detection of neutrons in a semiconductor device that contains boron carbide. In testing the device, P-N or P-I-N junctions are generally the same. Therefore, one skilled in the art may use the testing device of FIG. 2 to detect neutron capture in a boron carbide homojunction diode, as well as a heterojunction diode. Thus, Applicants respectfully request that the rejection based upon 35 U.S.C. § 112, second paragraph, be withdrawn and further submit that claims 2, 3 and 13 are in condition for allowance.

Claims 1, 4-7, 9, 11 and 12 have been rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 5,940,460 to Seidel et al. ("the Seidel reference"). Further, claims 8 and 10 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the Seidel reference. The Seidel reference provides for a solid state neutron detector array where each

detector includes a substrate 12, a semiconductor active region ~~14, 16 and~~ a neutron detector layer 22.

The invention of claim 1 relates to a neutron detector device having a sensing mechanism with a layer of boron carbide semiconductor that is an electrically active part of the detection device. The neutron detector device also includes a monitoring device that records the changes in the boron carbide layer detected by the sensing mechanism. By providing a construction in accordance with claim 1, numerous advantages are realized. For example, the neutron detector is able to achieve a high efficiency because the reaction of ^{10}B with neutrons results in ions which very efficiently ionize atoms in the surrounding electrically active semiconductor where the charge can be swept out efficiently (Page 8, line 30; Page 9 lines 1-3).

None of the references of record either, when considered singly or in combination with one another, show or suggest a neutron detecting device having a layer of boron carbide semiconductor that is an electrically active part of the device as recited in claim 1. It is well established principle that the prior art must teach each and every limitation in order to anticipate the claimed invention. See Apple Computer, Inc. v. Articulate Systems, Inc., 234 F.3d 14, 57 USPQ.2d 1057 (Fed. Cir. 2000). In the Seidel reference, the semiconductor active region is the electrically active part of the detector, not the neutron converter layer (Col. 4, lines 1-3). In addition, the Seidel reference teaches away from having a boron carbide active portion of the detector given the fact that the semiconductor active region is described as being formed of silicon, germanium, SiC, diamond, GaAs, GaP, PbO and CdS as opposed to boron carbide (Col. 4, lines 3-9). The Seidel reference only refers to B_4C as one boron containing neutron converter layer which is not an electrically active part of the device. Further, the Seidel reference mentions the possibility that the neutron converter layer may be deposited on the semiconductor active

region as an electrical contact in place of contact 18. However, the use of the term "contact" shows that the Seidel reference regards the B_4C layer as metallic, not a semiconductor.

Moreover, the Seidel reference does not address the problem the neutron detector described in claim 1 of the invention intends to solve. In particular, incorporating the boron-rich alloy as an electrically active semiconductor part of the detector allows for the overall thickness of the device to be reduced while retaining high efficiency of neutron detection (Page 5, lines 22-24). In contrast, the Seidel reference resembles the prior art discussed in the present patent application where boron is an external conversion layer to a silicon diode and a GaAs diode where the maximum efficiency is traditionally less than 5% (Page 2, lines 12-13).

Since none of the references to teach or suggest all of the limitations in independent claim 1, Applicants respectfully request withdrawal of the § 102(e) rejection of claim 1 for at least the above references reasons. As claims 4-11 depend either directly or indirectly from claim 1, these claims are believed to be in condition for allowance for at least the above cited reasons. As such, Applicants respectfully request withdrawal of the § 102(e) rejection of claims 4-11 as well. Each of claims 1 and 4-11 are believed to be in condition for allowance and such favorable action is respectfully requested.

Dependent claims 4-11 recite additional features of the inventive construction and are further distinguishable from the references of record. For example, claim 10 provides for a boron carbide layer that contains at least 80% ^{10}B. In contrast, the Seidel reference makes no reference to the amount of enrichment of the neutron converter layer, and does not suggest enrichment of at least 80%. Given the lack of suggestion or teaching in the Seidel reference or any other cited references as to the enrichment level of the neutron converter layer, Applicants request the withdrawal of the rejection of claim 10 for this additional reason.

Independent claim 12 provides for a method for detecting neutrons which includes 1) positioning a neutron detecting device in a location to allow the device to intercept a stream of neutrons, the detector comprising a layer of boron carbide that is an electrically active part of the device and a sensing mechanism coupled to the boron carbide layer, 2) introducing at least one neutron traveling in a direction to be intercepted by the boron carbide layer, and 3) monitoring the interaction of the neutron with the boron carbide semiconductor where the sensing mechanism detects changes in the boron carbide layer caused by the interception of neutrons.

None of the references of record either, when considered singly or in combination with one another, show or suggest a method of detecting neutrons that includes a boron carbide layer that is an electrically active part of a neutron detecting device. The arguments that were set forth with regard to claim 1 are equally applicable to the allowability of claim 12. Since none of the references to teach or suggest all of the limitations in independent claim 12, Applicants respectfully request withdrawal of the § 102(e) rejection of claim 12 for at least the above references reasons. Claim 12 is believed to be in condition for allowance and such favorable action is respectfully requested.

Claims 1 and 4-12 have ben rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 5,707,879 to Reinitz ("the Reinitz reference") in view of the Seidel reference and conventional art. Applicants respectfully traverses this rejection.

Applicants submit that a prima facie case of obviousness has not been established with respect to independent claims 1 and 12 since the cited references are not properly combinable. "It is well-established that before a conclusion of obviousness may be made based upon a combination of references, there must have been a reason, suggestion or motivation to lead an inventor to combine those references." Pro-Mold and Tool Co. v. Great Lakes Plastics,

Inc., 37 USPQ.2d 1626 (Fed. Cir. 1996). "The fact that a prior art device could be modified so as to produce the claimed device is not a basis for an obviousness rejection." In re Gordon, 221 USPQ 1125 (Fed. Cir. 1984). The need or desire to modify the reference must be more than merely apparent. The showing must be both clear and particular. See Ruiz v. A.B. Chance Co., 234 F.3d 654, 665 (Fed. Cir. 2000) (citing In re Dembiczak, 53 USPQ.2d 1769 (Fed. Cir. 2000)).

None of the patents relied upon by the Examiner are combinable because they do not suggest the combination with the required clarity and particularity. As stated above, the neutron converter layer in the Seidel reference does not operate as an active semiconductor region. Therefore, there is nothing in either of the references that teach or suggest that the semiconducting material in the Reinitz reference which has helium three (^3He) introduced therein could be replaced with the boron carbide neutron converter layer provided in the Seidel reference.

Even if the references of record are combinable, such a combination does not teach or suggest a neutron detecting device having a layer of boron carbide semiconductor that is an electrically active part of the device as recited in amended claims 1 and 12. As stated above, the Seidel reference fails to teach or suggest the electrically active boron carbide semiconductor. The Reinitz reference fails to add anything to the Seidel reference except to specify a substrate having helium three either uniformily throughout the material or extending deep into the material occupying a substantial portion of the substrate volume (Col. 3, lines 2-4; FIGS. 2 and 3). The helium three is not part of the material, but is only introduced therein. As with the Seidel reference, the Reinitz reference fails to teach or suggest a boron carbide semiconductor that is an electrically active *part* of the sensing mechanism. Thus, the references of record fail to teach or

suggest all of the limitations included in claims 1 and 12, and Applicants respectfully request that the § 103(a) rejection of claims 1 and 12 be withdrawn.

As claims 4-11 depend either directly or indirectly from claim 1, these claims are believed to be in condition for allowance for at least the above cited reasons. As such, Applicants respectfully request withdrawal of the § 103(a) rejection of claims 4-11 as well. Each of claims 1 and 4-12 are believed to be in condition for allowance and such favorable action is respectfully requested.

Conclusion

Applicants respectfully submit that claims 1-13 are in condition for allowance and request such favorable action. Should the Examiner believe any issues are outstanding, the Examiner is encouraged to call the undersigned at (816) 474-6550.

Attached hereto is a marked-up version illustrating the changes made to the claims by virtue of the current amendment. The attached page is captioned **"Version with markings to show changes made."**

Respectfully submitted,

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Serial No. 09/856,966

VERSION WITH MARKINGS TO SHOW CHANGES MADE

Please make the below-indicated amendments to the claims. Material enclosed by brackets is to be removed and material which is underlined is to be added.

In the Specification

The paragraph located below "CROSS-REFERENCE TO RELATED APPLICATIONS" which begins and ends on page 1, line 9 was replaced with the following paragraph:

> – [Not Applicable.] <u>This application was filed under 35 U.S.C. § 371 based upon PCT Application Number PCT/US99/28038, filed on November 24, 1999 which takes priority from U.S. Provisional Application Number 60/109,898, filed on November 25, 1998.</u> –

The paragraph beginning on page 6, line 26 and ending on page 7, line 2 was replaced with the following paragraph:

> – The detector area of these heterojunction diodes was about 1 cm^2, and wired in a "mesa" geometry. The neutron source was a small TRIGA-type reactor (V.A. Medical Center, Omaha, NE) with a flux of $1.6x10^6$ n/cm^2•s based on calculations for the fission chamber. A heterojunction diode, reversed biased to about 3 V, was wired for pulse counting as shown in Figure 2 and inserted into the reactor. The resulting count rates with insertion are plotted in Figure [3] <u>4</u>. Background and noise counts are in the range of 250 to 300 Hz, and within the reactor, the count rate rises to $2x10^5$ Hz. –

The paragraph beginning on page 7, line 11 and ending on page 7, line 27 was replaced with the following paragraph:

> – Given that almost all counts are attributable to neutrons and that the boron carbide film is about 1000 nm thick, the detection efficiency is thus about 1% <u>as best seen in FIG. 5</u>. Given that devices can be made with boron carbide of 50 [nm] <u>micrometers</u> to 100 [nm] <u>micrometers</u> in thickness and with depletion layers

extending several [nanometers] <u>micrometers</u>, the single (thermal) neutron detection efficiencies are, conservatively, expected to reach 80% and higher in devices which simultaneously have exceedingly low γ-ray sensitivity (< 1% detection efficiency for all energies greater than 100 keV and < 0.01% for all energies above 0.5 MeV, assured by the use of boron as the dominant atomic species) <u>as best seen in FIG. 6</u>. Since the neutron - ^{10}B interaction results almost exclusively in the yield of highly ionizing lithium ions and alpha particles of total kinetic energy about 1.5 MeV and the boron atoms form the major species in the active semiconducting regions of the devices, the boron-carbon alloy layer of the detector yields an enormous internal gain (considerably greater than 10^5) which is essentially noise-free and comparable with the gain of the intensifiers and photomultipliers commonly used in scintillation-based detectors and imagers. By using exclusively ^{10}B enriched boranes in the PECVD fabrication process, detection efficiency with thinner films can be considerably improved compared with devices whose ^{10}B content reflects the natural isotopic abundance, about 19% ^{10}B.–

The paragraph beginning on page 9, line 15 and ending on page 9, line 23 was replaced with the following paragraph:

– This invention can be used in various forms of solid-state neutron detectors presenting entrance detecting areas of order μm^2 to m^2. These detectors are capable of being implemented with very thin detecting and electrically active regions (≤ 1 μm minimum effective electrical thickness), with very low mass per unit detecting area, with efficiencies ranging up to nearly 100% even for single neutrons, with real-time response, with high spatial resolution (≤ 1 μm minimum), and with high temporal resolution. Of course, implementation may not always need to, or be able to, employ each of these attributes. [Voltage] <u>As best seen in FIG. 3, voltage</u> and power needs are slight, as are charge pulse processing requirements. –

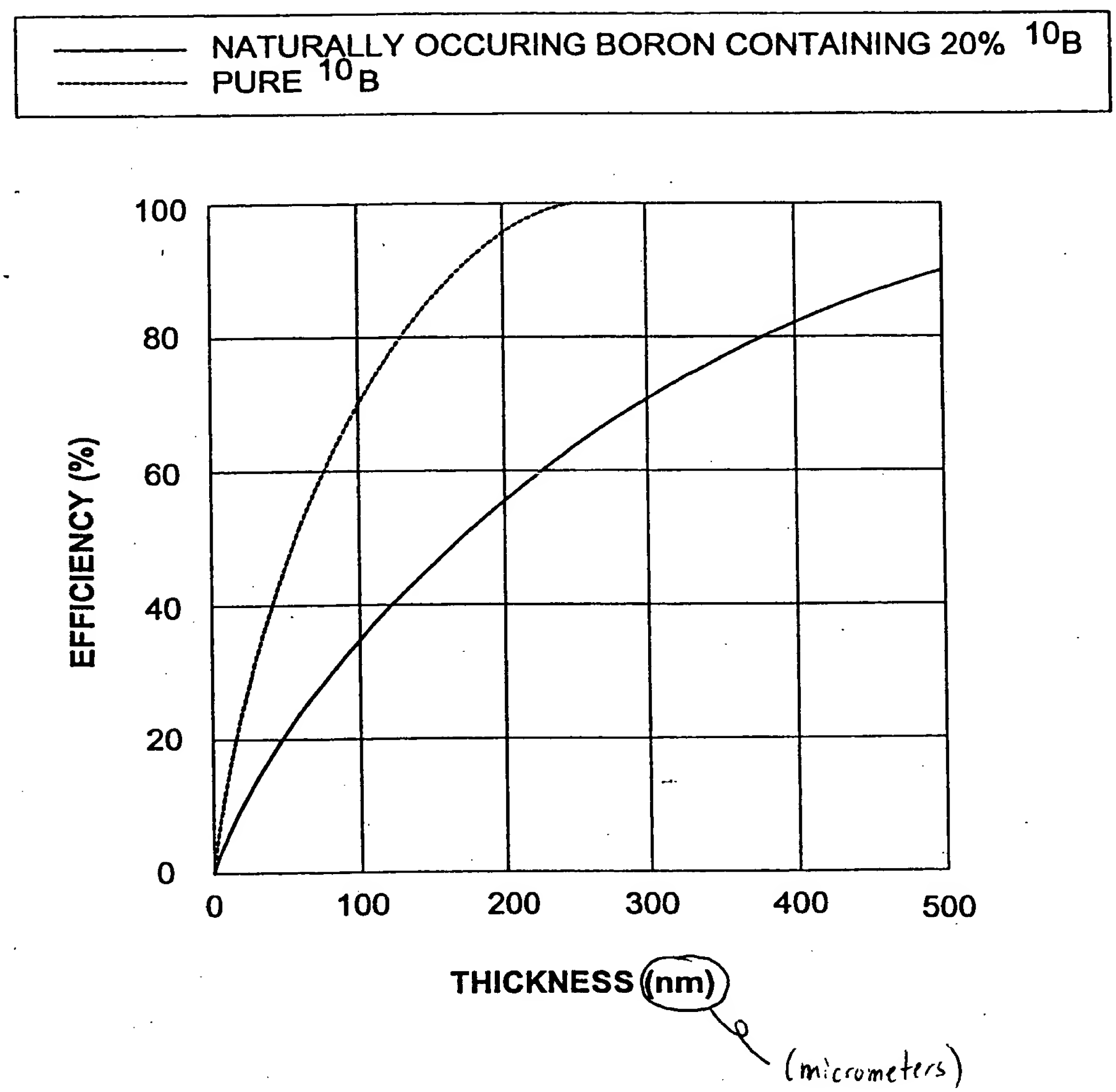
NATURALLY OCCURING BORON CONTAINING 20% ^{10}B
PURE ^{10}B
EFFICIENCY (%)
0
20
40
60
80
100
0
100
200
300
400
500
THICKNESS (nm)
(micrometers)

FIG. 6.